DEHYDRATION AND REHYDRATION OF APPLES

by

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TABLE OF CONTENTS

INTRODUCTION

The shortage of food is one of the major problems which India is facing these days. Since her independence fifteen years ago she has been trying her utmost to become self-sufficient in food but due to certain unavoidable circumstances she has not been able to achieve her goal. The main reasons responsible for this failure are:

1. An increase in population at a very rapid rate as compared with the increase in food production.

2. A majority of the farmers are illiterate and their land holdings are small.

3. Food is wasted on a very large scale due to the lack of preservation methods.

With the improvement in the standard of living the taste of the people is gradually shifting from dried fruits towards fresh fruits. The lack of refrigeration and storage facilities are hurdles in the way of supplying fruits in the fresh state during off seasons. Much spoilage occurs during the harvest period. At present, the only practical way to cope with the demand for fruit is to dry the fresh fruit by good methods and then to rehydrate it in such a way that rehydrated fruit will closely resemble the fresh fruit, especially with respect to flavor, aroma, shape, color, and texture.

Dr. George A. Filinger, a horticulturist of Kansas State University, is of the opinion that a method of dehydration that would fit the situation prevalent in India would also help the food problem to a great extent. "Suppression or elimination of the agents of spoilage" is the principal upon which his theory is based. He believes "wastage of food" is an important reason for the food shortage.

After careful consideration of the problem the writer started a project on the preservation of fruits. He is trying to devise a method which should not only be economical but should also be practical and dependable. The eyes of millions of the world are on such efforts.

It seems that at present dehydration is the answer for India.

REVIEW OF LITERATURE

The objectives of this study were to determine the effect of dehydration (the process of removing surplus water from plant and animal tissues without the destruction of the cellular structure or the impairment of nutritive value) and rehydration (the process of reconstituting tissues by supplying water) on apple tissues.

One of the important areas in the commercial utilization of apples is to preserve this fruit for use in other prepared foods. The methods of preservation used are drying, canning, freezing, and by chemical treatment. The fruit is preserved as slices, chunks, cubes, or pulped in the form of sauce. These products retain more or less not only of the characteristic flavor but also of the texture of the apples when used in the cooked form according to Smock and Neubert (88).

The process of preparing the fruit for drying in the sun differs somewhat for different kinds of fruits. Whatever the steps in the process the end objective is the same; the preservation of the fruits by reducing moisture content so that bacteria, yeast, and molds cannot develop and at the same time produce dried fruit with a desirable flavor and an attractive appearance. Mrak and Phaff (70) and Cruess (21) state that these steps include cleanliness and proper selection. They further state that it is expected that sun drying of fruits will be employed less and less and that dehydration will

eventually become the accepted method of drying. This swing away from sun-drying to dehydrating has come about because of a greater possibility of producing a cleaner, better quality of dried fruit by the latter method. In some cases and in periods of high labor costs dehydration may actually be cheaper than sun-drying. When labor costs are low, however, the reverse may be true. The use of dehydration cuts the drying time, it minimizes losses due to bad weather conditions and it is more suitable for mechanization, hence reducing labor requirements.

Hanson and Sidney (47) stated, "We had always felt that the best dehydrated products were freeze-dried. They reconstituted rapidly and almost completely and they had a fine quality but the freeze-drying equipment available at that time, useful as it was for smaller quantities of costly thermolabile products, appeared to hold no promise of commercial feasibility for the large scale drying of foods. Problems of engineering design, uniform reproducibility, etc. still confront us but the major fact has been demonstrated, that drying on a much larger and more commercially attractive scale than before can be performed in a vastly reduced and more reasonable time to give products with the reconstitution and quality of classical freeze-drying."

Apples possessing good cooking qualities are most desirable for use in preparing dried, canned, and frozen products. The general preference is for varieties of relatively high acid content, distinctive flavor and a firm texture that withstands cooking without becoming mushy according to Denning and Tate (27) and Filinger (34).

The varieties used in processing depend somewhat on the apple crop and market conditions. Smock and Neubert (88), Blink and Willets (10), and Tressler and Evers (93) advise that of the common varieties the Jonathan, Winesap, Grimes Golden, and Wealthy are considered suitable for processing. Further

study on this subject by Smock and Neubert (88) indicated that the Delicious, the most common and most extensively grown variety in the United States, is considered unsuitable for processing because of its low acid content and its tendency, particularly when over mature, to break down during preparation and processing.

The factors governing the quality of apples for fresh market use apply equally in determining the quality of fruit for processing. Care must be exercised in picking and handling apples if the best quality processed products are to be obtained. According to Fitch and Francis (39) and the U.S.D.A. (96)(97) the fruit should be mature, firm and free from diseases and decay.

Smock and Neubert (88) say that it is a general practice to wash and sort the fruit before processing, particularly when field run apples are used or when packing house fruit has been stored for some time. Frazier (41) reported that the washing of fresh fruits and vegetables before processing removes soil and other organisms that might be resistant to the heat process during canning of the food.

A preliminary sulfur treatment is usually given to apples after trimming to serve as a bleach and to protect them against darkening during preparation. This may be accomplished by passing the fruit through a tunnel containing sulfur dioxide gas or by immersing or spraying with a 1 to 3% solution of sodium bisulfite or sulfurous acid according to Smock and Neubert (88). Lazar and Smith (59) and Kaufman and Power (54) considered the use of sulfur dioxide to inhibit enzymatic browning in the drying of apples as a well-established practice. Frazier (41) reported that the main purpose of sulfuring is the conservation of color and not the inhibition of micro-organisms, although molds are affected more readily than bacteria. Child and Niles (19) considered sulfur

dioxide to have protective influence on vitamin C content.

According to Frazier (41) salt causes high osmotic pressure and hence plasmolysis of cells, it dehydrates the food by drying out and tying up moisture, it further ionizes the chlorine ions which are harmful to micro-organisms and reduces the solubility of oxygen in the moisture. Salt also sensitizes the cells against carbon dioxide and interferes with the action of proteolytic enzymes.

Blanching washes the food, sets the color, softens the tissues to aid in packing, helps form a vacuum, and kills some organisms according to Frazier (41). He further reported that fruits, prior to processing, are seldom blanched because it would cause physical damage.

The shrivelled appearance that is characteristic of dried fruit can be corrected by soaking the fruit for a short time in cold water before it is cooked say Fitch and Francis (39). They further indicated that during the soaking of dried fruits, osmotic pressure forces are at work with the skins and walls of the myriads of cells of fruits acting as a permeable membrane. Thus, when such a fruit is put into water, the cells, due to higher concentration of their solution, will have a higher osmotic pressure than that of the surrounding water and as a result more water will diffuse into the fruit than out thereby causing it to become more plump. The diffusion of water and soluble salts will continue with the accompanying swelling of the fruit until equilibrium is set up between the concentration of solutes within the cell and the surrounding solution, or until the membrane bursts, or until cooking is started in which case the permeable membrane is destroyed by heat. Charley (16) reported that fruit should be soaked for half an hour just after bringing the water to boiling temperature. Lazar and Smith (59) and Kaufman and Powers (54), during an experiment, found blanched fruit reconstituted to

87% of the fresh weight when soaked one or two hours in cold water compared with 78% for unblanched fruit. However, both types reconstituted close to 100% when soaked longer or when reconstituted by heat. Chenoweth (18) stated that sugar adapts the finished product to taste and aids in giving the proper consistency while U.S.D.A. (96)(97) reported that sugar helped canned fruit in holding its shape, color, and flavor. Nason (71) reported that sugar will be absorbed by cooking fruit more rapidly if it is added to the fruit after softening its cell walls by simmering. She described an ideal cooked fruit as one in which sugar is equally distributed in both juice and fruit.

MATERIALS AND METHODS

The following three varieties of apples were selected for this project: Jonathan, Winesap, and Delicious.

1. Selecting - Only fruits of good quality were used.
2. Washing - The fruits were washed with water to remove a) spray materials, b) dirt and dust, and c) to lessen microbial organisms.
3. Peeling and coring - The fruits were peeled and then cored with fruit corer.
4. Trimming and slicing - This was done to remove the bits of skin, bruises, and defects remaining after the peeling operation, then the fruits were cut into conventional twelve radial sections.
5. Treating - The fruits of each sample of 25 apples, after sectioning, were treated as follows:
   a. Control - Fresh apple slices were dried without any chemical treatment.
   b. Salted - The slices were dipped for two minutes into a 2% salt solution.

c. Sulfured - The fruits were dipped for two minutes in a 2% sodium sulfite solution.

d. Blanched - The cut fruits were placed in a perforated stainless steel basket and placed for two minutes in boiling water.

The fruit slices were then dried by the following methods:

1. Sun-dried - The slices of the fruit after treating with sulfur and no chemical (control) were dried under the sun.
2. Freeze-dried - The slices of the apples, after treating with sulfur, no chemical (control), were placed in a big bottle in such a way that every apple slice had all the sides exposed equally in the bottle. The bottle was placed in a slanting position on dry ice for four hours. After this, these were subjected to a vacuum of 30 microns for sixteen hours.
3. Fried for chips - The slices of the apple were held at 390° F in vegetable shortening for one minute and for two minutes, with and without antioxident.
4. The slices, after treating with sulfur, salt, blanched, and control were dried in an oven at a temperature of 160° F for twelve hours.
5. The slices, after treating with sulfur, salt, blanched, and control were dried in a dehydrator at a temperature of 130° F for 72 hours.

Since the dried fruit must be rehydrated for consumption a study was made of the methods of reconstituting the dried fruit.

Apple slices, after drying at a temperature of 130° F for 72 hours were rehydrated in the following manner:

a. Duplicate gm. samples of each of four treatments of dried apples were

each placed in a pan.

b. One hundred and seventy-five ml. of water at 50° F was put in each pan.

c. The samples were brought to a boil and allowed to soak in the hot water for thirty minutes.

d. Ten gms. of granulated sugar was added to one of the samples of each treatment after simmering for one minute.

e. The samples were simmered for a total of five minutes.

f. The samples were cooled and placed in a refrigerator for fourteen hours.

g. After this period the water or syrup left unabsorbed by the apple slices was discarded.

h. The rehydrated samples were then judged by a panel of nine persons (two professors and seven students) for aroma, color, shape, flavor, and texture.

RESULTS AND DISCUSSION

The fruits dried by sun-drying, after treating with sulfur, were whiter in color but were poor in texture and shape. The dried untreated samples were dark in appearance. On the whole, sun-dried fruits were of inferior quality, developed off-flavors, and became moldy. Spoilage was due to high moisture content.

The fruits dried by freeze-drying were of superior quality. The sulfur treated samples had a good texture, flavor, and were whiter in color. The dried apple slices maintained their original shape and were not shrivelled which may be due to extraction of liquids from the frozen apple slices in the form of vapors. In resume, freeze-dried samples had a good color, flavor,

texture, aroma, shape, and stored well, but due to the requirement of high technical skill and the unavailability of the equipment in large scale this method was considered to be impractical on a large scale for use in India.

Apple chips fried for one minute became moldy within a few days while those fried for two minutes were too dark in color. The apple chips fried in vegetable shortening containing anti-oxidant (Butylated Hydroxy Anisole and Butylated Hydroxy Toluene) were light in color but the results were not satisfactory.

Little difference was found in the quality of dried apples between the fruits dried at 130° F and 160° F. The fruits treated with salt were white in color but were tough in texture. The fruit treated with sulfur before drying were white and had a good texture. Control treated dried samples were brown with a medium texture. The samples blanched before drying were shrivelled in appearance and were light brown with a medium texture.

Since the dried fruit must be rehydrated for consumption a study was made of the methods of reconstituting the dried fruit.

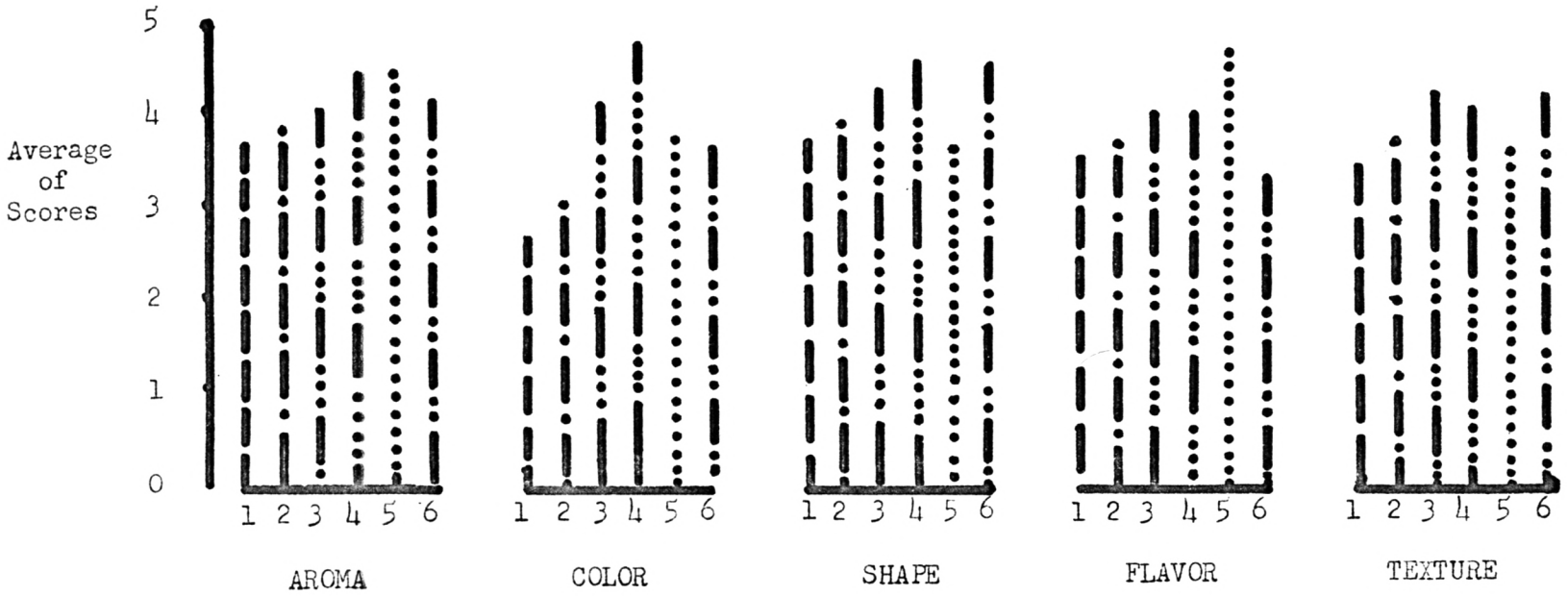
The rehydrated samples were judged by a panel of nine persons (two professors and seven students) for aroma, color, shape, flavor, and texture (Fig. 1).

The average scores for the three varieties of apples which were blanched before drying and which were cooked with and without sugar during rehydration are presented in Chart 1. Delicious received a higher score in color and shape when cooked without sugar; in texture, Delicious cooked with sugar received a higher score. Winesap received a higher score in aroma and flavor when cooked with sugar. Jonathan received the lowest score of the three varieties both with and without sugar.

Figure 1. Rehydrated Winesap apple slices.

Key:	Sample No.	Name of Treatment
	1	Sulfured
	2	Blanched
	3	Salted plus sugar
	4	Control plus sugar
	5	Salted
	6	Blanched plus sugar
	7	Control
	8	Sulfured plus sugar

Chart 1. Comparison of average scores for three varieties of apples blanched for two minutes before drying and rehydrating.



1. Jonathan with Sugar
2. Jonathan without Sugar
3. Delicious with Sugar
4. Delicious without Sugar
5. Winesap with Sugar
6. Winesap without Sugar

The comparison of the average scores for three varieties of apples treated with salt before drying and cooked with and without sugar during rehydrating was made and are presented in Chart 2. Jonathan cooked with sugar received the highest score in aroma, flavor, and texture; in color, Jonathan cooked without sugar produced the highest score. Winesap received the highest score in shape when cooked with sugar. Sugar produces a beneficial effect on aroma, shape, flavor, and texture for all the three varieties.

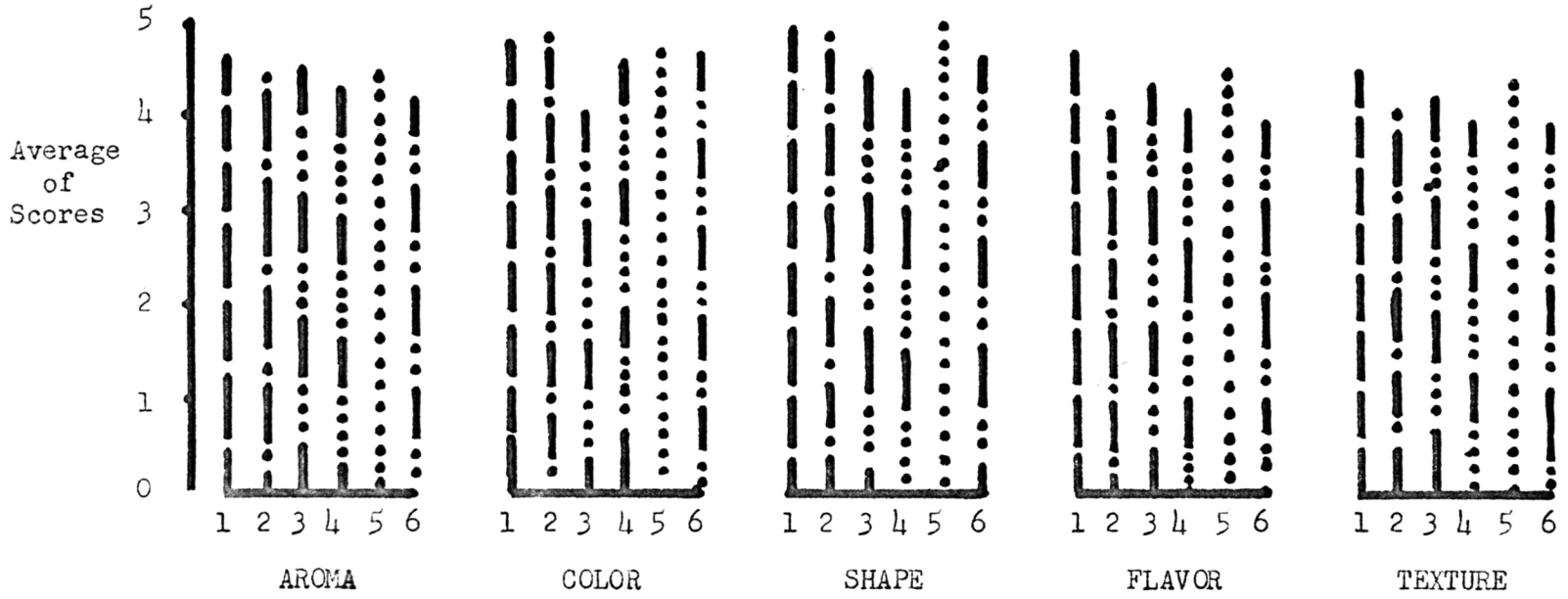
The average of scores for the three varieties of apples treated with a 2% sulfur solution before drying and rehydrated with and without sugar was highest for Jonathan in respect to aroma, color, shape, flavor, and texture. (Chart 3)

The average of scores for the three varieties of apples dried without pre-treatment (control) and rehydrated by cooking with and without sugar was highest in all factors scored for Delicious cooked with sugar. Comparing Winesap and Jonathan, Winesap definitely gave better results than Jonathan in all the factors scored. Sugar showed a beneficial effect on aroma, color, shape, flavor, and texture of all the three varieties. (Chart 4)

Delicious received the highest score in blanched and control samples, both when cooked with or without sugar. Jonathan received the highest score in salted and sulfured samples, both when cooked with or without sugar. Sugar showed a definite beneficial effect on the quality of Delicious, Jonathan, and Winesap when they were treated with salt and no pre-treatment (control) before drying. (Chart 5)

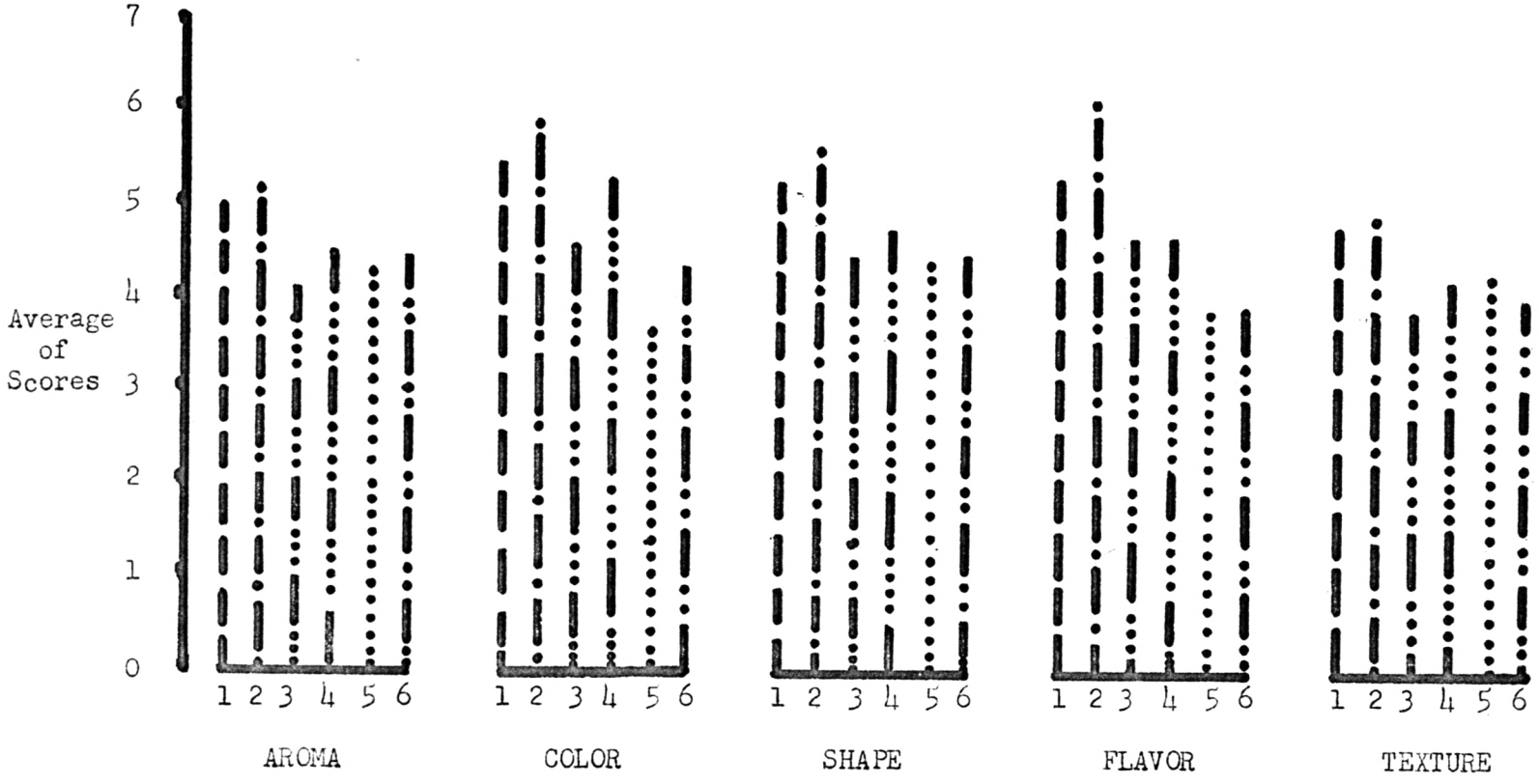
The treatment given to apples during drying and rehydrating were compared in Chart 6. Apples treated with salt and control treatments respectively, received a higher score when cooked with sugar. Apples treated with blanching and sulfur treatments got higher scores when cooked without sugar.

Chart 2. Comparison of average scores for three varieties of apples treated with 2% salt solution before drying and rehydrating.



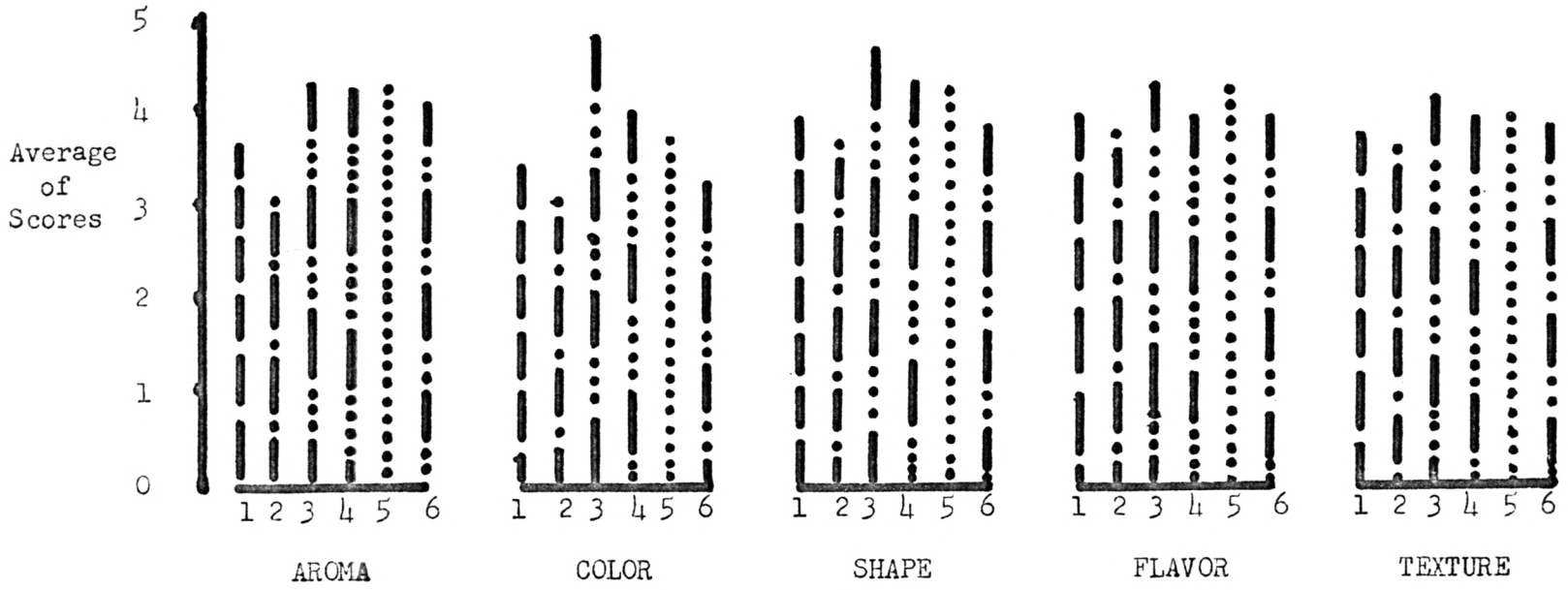
1. Jonathan with Sugar
2. Jonathan without Sugar
3. Delicious with Sugar
4. Delicious without Sugar
5. Winesap with Sugar
6. Winesap without Sugar

Chart 3. Comparison of average scores for three varieties of apples treated with 2% sulfur solution before drying and rehydrating.



1. Jonathan with Sugar
2. Jonathan without Sugar
3. Delicious with Sugar
4. Delicious without Sugar
5. Winesap with Sugar
6. Winesap without Sugar

Chart 4. Comparison of average scores for three varieties of apples dried without pre-treatment (control) and rehydrating.



1. Jonathan with Sugar
2. Jonathan without Sugar
3. Delicious with Sugar
4. Delicious without Sugar
5. Winesap with Sugar
6. Winesap without Sugar

Chart 5. Comparison of average scores for quality of the three varieties studied.

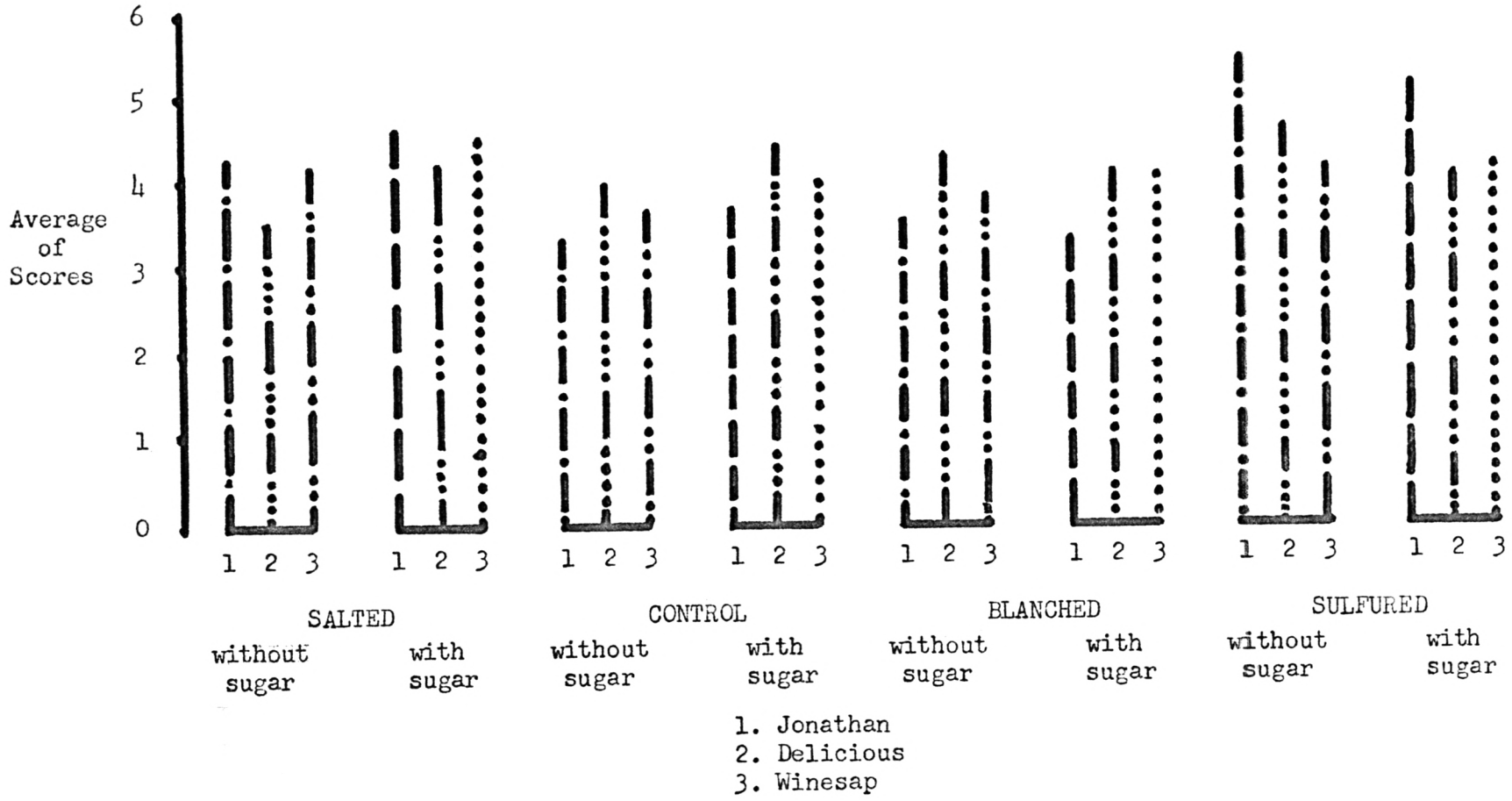
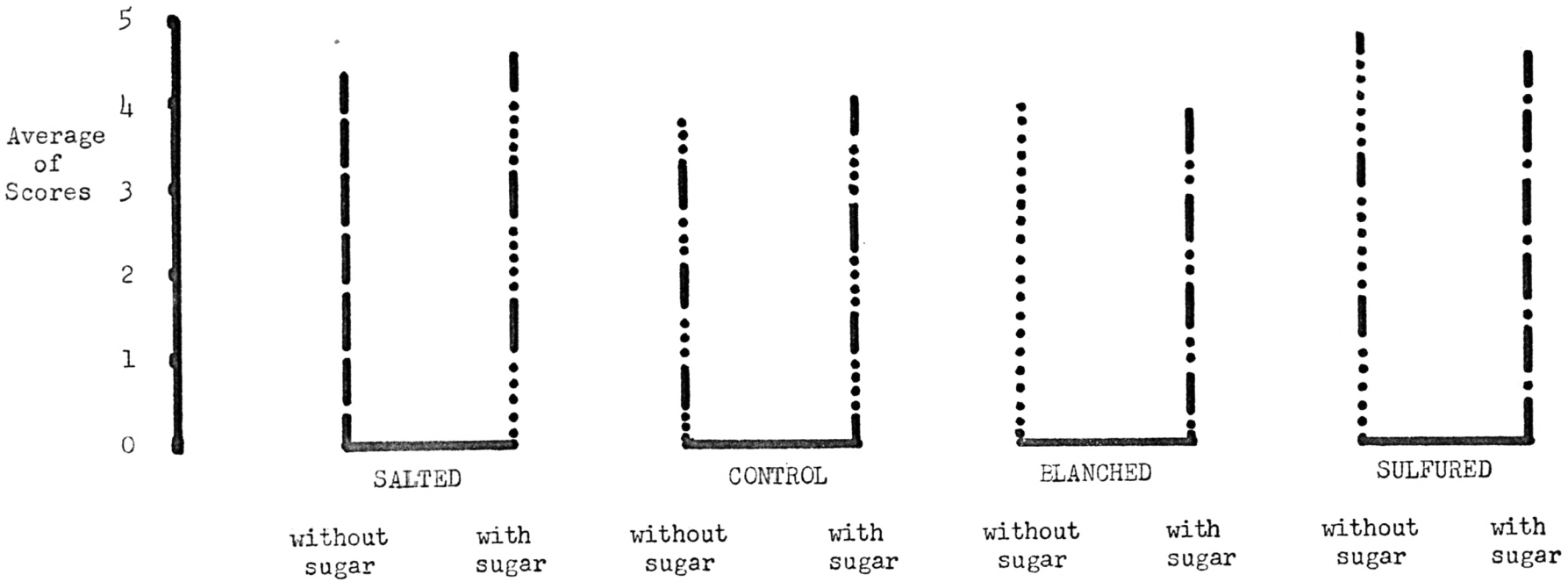


Chart 6. Comparison of treatments given to apples during drying and rehydrating on the basis of average scores.



Tables 1 and 2 include all the data which was presented to the Statistics Department for statistical analysis. The average of scores for rehydrated apples and the differences among treatments and varieties when cooked with and without sugar are included. Tables 3 to 7 present the statistical analysis.

Table 1. Average of scores given by a panel for rehydrated apples.

Variety	Replication	Cooked with 20% sugar																			
		Control					Salted					Sulfured					Blanched				
		Aroma	Color	Shape	Flavor	Texture	Aroma	Color	Shape	Flavor	Texture	Aroma	Color	Shape	Flavor	Texture	Aroma	Color	Shape	Flavor	Texture
Jonathan	1	3.0	3.0	3.2	3.5	3.4	4.4	4.2	4.4	4.4	4.2	4.8	5.9	6.0	5.5	4.6	3.4	2.4	3.2	3.3	3.0
	2	3.3	3.4	3.6	3.9	3.9	4.8	5.0	4.9	4.8	4.7	5.0	4.4	5.1	5.5	4.9	3.7	2.5	3.4	3.6	3.2
	3	3.8	3.7	3.9	4.3	3.8	5.1	5.1	5.4	5.0	4.5	5.1	5.2	5.1	5.0	4.4	3.1	2.0	3.5	3.1	3.2
	4	2.5	2.3	3.4	3.1	3.1	4.2	4.8	5.0	4.6	4.6	4.8	5.8	5.2	5.1	4.9	3.8	3.9	5.0	4.3	3.8
	5	5.1	4.6	5.2	5.1	4.6	4.4	4.6	4.9	4.4	4.3	4.9	5.9	4.8	5.2	4.9	3.8	2.7	3.4	3.6	3.8
Delicious	1	4.4	5.1	4.8	4.6	4.5	4.5	4.9	5.0	4.2	4.2	4.4	6.0	6.0	4.2	3.9	3.7	4.3	4.8	4.1	4.1
	2	4.1	4.1	4.2	4.0	3.8	4.0	3.5	3.4	3.5	3.4	4.8	5.8	5.2	4.4	4.1	4.6	4.1	3.6	3.8	4.1
	3	4.3	5.2	5.8	4.3	4.2	4.2	2.8	3.9	4.0	3.5	4.1	4.1	4.2	4.4	4.4	3.3	3.9	4.8	4.2	4.6
	4	3.3	3.5	3.5	3.6	3.5	4.5	5.3	5.1	5.1	4.8	3.6	3.4	3.5	3.5	3.9	4.3	4.7	4.3	4.3	4.5
	5	5.0	6.0	4.8	4.9	4.8	4.8	5.6	5.0	4.9	4.7	3.6	3.2	3.5	3.1	3.0	4.2	3.7	3.9	4.0	3.9
Winesap	1	4.3	3.8	4.5	4.6	4.3	4.6	4.6	5.0	4.7	4.8	4.0	3.4	4.1	4.8	4.6	5.1	4.1	4.5	4.8	5.0
	2	3.8	2.0	3.3	3.5	3.6	4.4	5.4	5.1	4.2	4.4	4.3	4.0	4.0	4.6	4.2	4.3	3.7	4.1	4.8	4.1
	3	4.3	4.1	4.3	4.1	4.1	4.5	5.2	4.9	4.3	4.3	4.6	5.2	5.3	5.1	3.9	4.2	3.8	4.5	4.8	4.0
	4	4.4	4.3	4.6	4.6	4.3	4.3	4.9	4.5	4.5	4.2	4.1	4.4	3.5	4.4	4.1	4.5	3.4	3.9	5.0	4.1
	5	4.2	4.0	4.0	4.5	3.6	4.2	5.1	5.1	4.6	4.0	4.3	5.3	5.0	4.5	4.5	4.2	3.9	4.5	4.1	3.9

Table 2. Average of scores given by a panel for rehydrated apples.

Variety	Replication	Cooked without 20% sugar																			
		Control				Salted				Sulfured				Blanched							
Jonathan	1	3.2	3.0	3.6	3.4	3.6	3.8	4.3	4.5	3.4	3.8	5.4	6.5	6.1	5.0	4.5	3.1	2.2	4.1	3.5	3.4
	2	4.4	3.5	4.1	3.8	3.5	4.7	5.1	4.8	4.3	4.0	5.1	5.5	5.6	5.2	4.6	4.1	3.4	3.8	3.0	3.4
	3	3.9	3.2	3.4	3.5	3.6	4.2	4.4	4.1	3.4	3.8	5.1	6.3	6.0	5.2	5.1	4.4	4.1	4.6	4.3	4.2
	4	3.0	2.6	3.8	3.0	3.5	4.7	5.0	5.0	4.8	4.5	5.0	5.6	5.5	5.8	5.2	4.0	3.1	4.3	4.0	4.2
	5	3.5	2.8	3.3	4.4	3.8	4.6	5.3	5.8	4.1	3.9	5.0	5.3	4.8	5.3	4.9	3.5	2.6	3.0	3.8	3.4
Delicious	1	4.6	5.2	5.2	4.3	3.9	4.2	5.7	5.6	4.3	3.8	4.0	6.0	5.5	4.3	4.2	4.1	4.8	4.3	4.0	3.9
	2	3.9	4.1	4.2	3.2	4.1	5.0	5.3	5.6	4.6	5.1	4.5	5.5	5.3	4.1	4.4	4.4	4.4	4.6	4.4	4.4
	3	4.5	3.3	4.0	4.1	3.6	3.8	3.7	3.2	3.9	3.2	4.9	5.9	4.6	5.2	4.1	4.9	5.9	5.4	5.3	5.0
	4	3.6	3.0	3.0	3.8	3.9	4.0	3.4	2.9	4.0	4.1	4.5	5.5	4.8	5.1	4.5	4.0	4.5	4.3	3.1	3.6
	5	4.3	4.1	4.9	4.3	4.4	4.4	4.6	4.1	3.6	3.6	4.4	3.3	3.5	4.4	3.8	4.9	4.1	4.4	3.5	4.0
Winesap	1	4.1	3.5	3.7	3.8	3.9	4.1	4.5	4.7	3.8	4.0	4.1	2.9	4.5	3.9	4.4	4.4	3.8	4.6	3.9	3.7
	2	3.7	2.4	3.2	3.6	4.4	4.0	4.0	3.8	4.4	3.6	3.9	4.0	3.2	3.4	3.7	4.2	4.0	5.9	3.3	3.4
	3	4.5	4.1	4.3	4.2	3.6	4.5	4.9	5.4	3.8	4.1	4.6	4.4	4.6	3.5	3.3	3.9	3.6	4.6	2.6	4.1
	4	4.0	2.6	4.0	4.1	3.5	4.2	4.8	4.4	4.1	4.2	4.2	4.4	5.2	3.4	3.6	4.0	3.1	3.3	3.7	3.3
	5	3.8	3.4	3.4	3.9	3.9	4.1	4.9	4.9	3.6	3.6	5.4	6.0	4.7	4.9	5.1	4.0	3.7	4.4	3.4	3.6

Table 3 shows the effect of treatment on color of the rehydrated apple varieties.

a. No significant difference was noted among varieties due to a wide fluctuation in scores.

b. Significant differences were noted among treatments. Mean of total average scores of —

1. Control - - - 109.4 divided by 30 equals 3.65
2. Blanched - - 110.4 divided by 30 equals 3.68
3. Salted - - - 140.9 divided by 30 equals 4.69
4. Sulfured - - 149.1 divided by 30 equals 4.97

Least square difference at .05 level is .45.

a. No significant difference was found between salted and sulfured treatment, salted and control treatment, control and blanched treatment, and salted and blanched treatment.

b. Significant differences were noted between sulfur and control treatment and sulfur and blanched treatment.

c. Salted and sulfured samples received the highest mean average scores.

Table 3. Effects of various treatments on color of rehydrated apple varieties.

		Cooked with 20% sugar					Cooked without 20% sugar				
		Cont	Salt	Sulf	Blan	Total	Cont	Salt	Sulf	Blan	Total
Jonathan	1	3.0	4.2	5.9	2.4	15.5	3.0	4.3	6.5	2.2	16.0
	2	3.4	5.0	4.4	2.5	15.3	3.5	5.1	5.5	3.4	17.5
	3	3.7	5.1	5.2	2.0	16.0	3.2	4.4	6.3	4.1	18.0
	4	2.3	4.8	5.8	3.9	16.8	2.6	5.0	5.6	3.1	16.3
	5	4.6	4.6	5.9	2.7	17.8	2.8	5.3	5.3	2.6	16.0
		17.0	23.7	27.2	13.5	81.4	15.1	24.1	29.2	15.4	83.8
Delicious	1	5.1	4.9	6.0	4.3	20.3	5.2	5.7	6.0	4.8	21.7
	2	4.1	3.5	5.8	4.1	17.5	4.1	5.3	5.5	4.4	19.3
	3	5.2	2.8	4.1	3.9	16.0	3.3	3.7	5.9	5.9	18.8
	4	3.5	5.3	3.4	4.7	16.9	3.0	3.4	5.5	4.5	16.4
	5	6.0	5.6	3.2	3.7	18.5	4.1	4.6	3.3	4.1	16.1
		23.9	22.1	22.5	20.7	89.2	19.7	22.7	26.2	23.7	92.3
Winesap	1	3.8	4.6	3.4	4.1	15.9	3.5	4.5	2.9	3.8	14.7
	2	2.0	5.4	4.0	3.7	15.1	2.4	4.0	4.0	4.0	14.4
	3	4.1	5.2	5.2	3.8	18.3	4.1	4.9	4.4	3.6	17.0
	4	4.3	4.9	4.4	3.4	17.0	2.6	4.8	4.4	3.1	14.9
	5	4.0	5.1	5.3	3.9	18.3	3.4	4.9	6.0	3.7	18.0
		18.2	25.2	22.3	18.9	84.6	16.0	23.1	21.7	18.2	79.0
		59.1	71.0	72.0	53.1	255.2	50.8	69.9	77.1	57.3	255.1
A x R: V		Cont	Salt	Sulf	Blan	Total					
Jonathan	1	6.0	8.5	12.4	4.6	31.5					
	2	6.9	10.1	9.9	5.9	32.8					
	3	6.9	9.5	11.5	6.1	34.0					
	4	4.9	9.8	11.4	7.0	33.1					
	5	7.4	9.9	11.2	5.3	33.8					
		32.1	47.8	56.4	28.9	165.2					
Delicious	1	10.3	10.6	12.0	9.1	42.0					
	2	8.2	8.8	11.3	8.5	36.8					
	3	8.5	6.5	10.0	9.8	34.8					
	4	6.5	8.7	8.9	9.2	33.3					
	5	10.1	10.2	6.5	7.8	34.6					
		43.6	44.8	48.7	44.4	181.5					
Winesap	1	7.3	9.1	6.3	7.9	30.6					
	2	4.4	9.4	8.0	7.7	29.5					
	3	8.2	10.1	9.6	7.4	35.3					
	4	6.9	9.7	8.8	6.5	31.9					
	5	7.4	10.0	11.3	7.6	36.3					
		34.2	48.3	44.0	37.1	163.6					
		109.9	140.9	149.1	110.4	510.3					

Cont - Control
Salt - Salt
Sulf - Sulfur
Blan - Blanched

Table 3 continued COLOR

Source of Variation	D. F.	Ss	Ms	F	Sig
Varieties	2	4.9054	2.4527	2.74	ns
Reps: V (a)	12	10.7276	.8940		
Trt A (Chem)	3	41.6089	13.8696	17.95	***
A x V	6	23.1759	3.8626	5.00	***
A x R: V (b)	36	27.8164	.7727		
Trt B (Sugar)	1	0	0	0	ns
B x V	2	1.1683	.5842	1.49	ns
A x B	3	3.7916	1.2639	3.22	*
A x B x V	6	1.2571	.2095	.53	ns
Error (c)	48	18.8480	.3927		
Total	119	133.2992			

N = 120

Total
S = 510.3
SS = 2303.35
- C = 2170.0508
Ss = 133.2992

Varieties
SS/40 = 2174.9562
- C = 2170.0508
Ss = 4.9054

Reps: V
SS/8 = 2185.6838
- V SS = 2174.9562
Ss = 10.7276

Trt A
SS/30 = 2211.6597
- C = 2170.0508
Ss = 41.6089

Table 3 continued COLOR

A x V	SS/10 =	2239.7410
	- C =	2170.0508
- A	Ss =	41.6089
- V	Ss =	4.9054
	Ss =	23.1759
A x R: V	SS/2 =	2278.2850
	- C =	2170.0508
- V	Ss =	4.9054
- R: V	Ss =	10.7276
- A	Ss =	41.6089
- A x V	Ss =	23.1759
	Ss =	27.8164
Trt B	SS/60 =	2170.0508
	- C =	2170.0508
	Ss =	0
B x V	SS/20 =	2176.1245
	- C =	2170.0508
- B	Ss =	0
- V	Ss =	4.9054
	Ss =	1.1683
A x B	SS/15 =	2215.4513
	- C =	2170.0508
- C	Ss =	41.6089
- B	Ss =	0
	Ss =	3.7916
A x B x V	SS/5 =	2245.9580
	- C =	2170.0508
- A	Ss =	41.6089
- B	Ss =	0
- V	Ss =	4.9054
- A x B	Ss =	3.7916
- A x V	Ss =	23.1759
- B x V	Ss =	1.1683
	Ss =	1.2571

Table 4 shows the effect of various treatments on the texture of rehydrated apple varieties.

a. No significant differences were noted among varieties due to wide fluctuations in scores.

b. Significant differences were noted among treatments. Mean of total average scores of —

1. Control - - - 116.7 divided by 30 equals 3.890
2. Blanched - - 116.9 divided by 30 equals 3.897
3. Salted - - - 124.0 divided by 30 equals 4.133
4. Sulfured - - 129.7 divided by 30 equals 4.323

Least square difference at .05 level comes to .24.

a. No significant difference was found between mean average scores of salted and sulfured treatments, salted and control treatments, salted and blanched treatments, and blanched and control treatments.

b. Significant differences were noted between sulfur and control treatments, and sulfur and blanched treatments. Salted and sulfured samples got the highest mean average scores.

Table 4. Effects of various treatments on texture of rehydrated apple varieties.

		Cooked with 20% sugar					Cooked without 20% sugar				
		Cont	Salt	Sulf	Blan	Total	Cont	Salt	Sulf	Blan	Total
Jonathan	1	3.4	4.2	4.6	3.0	15.2	3.6	3.9	4.5	3.4	15.4
	2	3.9	4.7	4.9	3.2	16.7	3.5	4.0	4.6	3.4	15.5
	3	3.8	4.5	4.4	3.2	15.9	3.6	3.8	5.1	4.2	16.7
	4	3.1	4.6	4.9	3.8	16.4	3.5	4.5	5.2	4.2	17.4
	5	4.6	4.3	4.9	3.8	17.6	3.8	3.9	4.9	3.4	16.0
		18.8	22.3	23.7	17.0	81.8	18.0	20.1	24.3	18.6	81.0
Delicious	1	4.5	4.2	3.9	4.1	16.7	3.9	3.8	4.2	3.9	15.8
	2	3.8	3.4	4.1	4.1	15.4	4.1	5.1	4.4	4.4	18.0
	3	4.2	3.5	4.4	4.6	16.7	3.6	3.2	4.1	5.0	15.9
	4	3.5	4.8	3.9	4.5	16.7	3.9	4.1	4.5	3.6	16.0
	5	4.8	4.7	3.0	3.9	16.4	4.4	3.6	3.8	4.0	15.8
		20.8	20.6	19.3	21.2	81.9	19.9	19.8	21.0	20.9	81.6
Winesap	1	4.3	4.8	4.6	5.0	18.7	3.9	4.0	4.4	3.7	16.0
	2	3.6	4.4	4.2	4.1	16.3	4.4	3.6	3.7	3.4	15.1
	3	4.1	4.3	3.9	4.0	16.3	3.6	4.1	3.3	4.1	15.1
	4	4.3	4.2	4.1	4.1	16.7	3.5	4.2	3.6	3.3	14.6
	5	3.6	4.0	4.5	3.9	16.0	3.9	3.6	5.1	3.6	16.2
		19.9	21.7	21.3	21.1	84.0	19.3	19.5	20.1	18.1	77.0
		59.5	64.6	64.3	59.3	247.7	57.2	59.4	65.4	57.6	239.6

A x R: V		Cont	Salt	Sulf	Blan	Total
Jonathan	1	7.0	8.1	9.1	6.4	30.6
	2	7.4	8.7	9.5	6.6	32.2
	3	7.4	8.3	9.5	7.4	32.6
	4	6.6	9.1	10.1	8.0	33.8
	5	8.4	8.2	9.8	7.2	33.6
		36.8	42.4	48.0	35.6	162.8
Delicious	1	8.4	8.0	8.1	8.0	32.5
	2	7.9	8.5	8.5	8.5	33.4
	3	7.8	6.7	8.5	9.6	32.6
	4	7.4	8.9	8.4	8.1	32.8
	5	9.2	8.3	6.8	7.9	32.2
		40.7	40.4	40.3	42.1	163.5
Winesap	1	8.2	8.8	9.0	8.7	34.7
	2	8.0	8.0	7.9	7.5	31.4
	3	7.7	8.4	7.2	8.1	31.4
	4	7.8	8.4	7.7	7.4	31.3
	5	7.5	7.6	9.6	7.5	32.2
		39.2	41.2	41.4	39.2	161.0
		116.7	124.0	129.7	116.9	487.3

Cont - Control
Salt - Salt
Sulf - Sulfur
Blan - Blanched

Table 4 continued TEXTURE

Source of Variation	D. F.	Ss	Ms	F	Sig
Varieties	2	.0831	.0416	.25	ns
Reps: V (a)	12	1.9666	.1639		
Trt A (Chem)	3	3.9089	1.3030	5.94	**
A x V	6	6.4829	1.0805	4.93	***
A x R: V (b)	36	7.8894	.2192		
Trt B (Sugar)	1	.5467	.5467	3.60	ns
B x V	2	.6966	.3483	2.29	ns
A x B	3	.6676	.2225	1.47	ns
A x B x V	6	.9361	.1560	1.03	ns
Error (c)	48	7.2880	.1518		
Total	119	30.4659			

N = 120

Total
S = 487.3
SS = 2009.31
- C = 1978.8441
Ss = 30.4659

Varieties
SS/40 = 1978.9272
- C = 1978.8441
Ss = .0831

Reps: V
SS/8 = 1980.8938
- V SS = 1978.9272
Ss = 1.9666

Trt A
SS/30 = 1982.7530
- C = 1978.8441
Ss = 3.9089

Table 4 continued TEXTURE

A x V	SS/10 =	1989.3190	A x B	SS/15 =	1983.9673
	- C =	1978.8441		- C =	1978.8441
- A	Ss =	3.9089	- A	Ss =	3.9089
- V	Ss =	.0831	- B	Ss =	.5467
	Ss =	6.4829		Ss =	.6676
A x R: V	SS/2 =	1999.1750	A x B x V	SS/5 =	1992.1660
	- C =	1978.8441		- C =	1978.8441
- V	Ss =	.0831	- A	Ss =	3.9089
- R: V	Ss =	1.9666	- B	Ss =	.5467
- A	Ss =	3.9089	- V	Ss =	.0831
- A x V	Ss =	6.4829	- A x B	Ss =	.6676
	Ss =	7.8894	- A x V	Ss =	6.4829
			- B x V	Ss =	.6966
Trt B	SS/60 =	1979.3908		Ss =	.9361
	- C =	1978.8441			
	Ss =	.5467			
B x V	SS/20 =	1980.1705			
	- C =	1978.8441			
- B	Ss =	.5467			
- V	Ss =	.0831			
	Ss =	.6966			

Table 5 shows the effect of various treatments on the flavor of rehydrated apple varieties.

a. No significant difference was found among varieties due to wide fluctuation in scores.

b. Significant differences were noted among treatments. Mean of total average scores of --

1. Control - - - 120.1 divided by 30 equals 4.003
2. Blanched - - 117.6 divided by 30 equals 3.920
3. Salted - - - 127.3 divided by 30 equals 4.243
4. Sulfured - - 138.0 divided by 30 equals 4.600

Least square difference at .05 level comes to .26.

a. No significant difference was found between the mean average scores of blanched and control treatments.

b. Significant differences were noted between sulfur and salted treatments, salted and blanched treatments, salted and control treatments, sulfured and blanched treatments, and sulfured and control treatments. Apparently sulfur treatments gave the best results.

Table 5. Effects of various treatments on flavor of rehydrated apple varieties.

		Cooked with 20% sugar					Cooked without 20% sugar				
		Cont	Salt	Sulf	Blan	Total	Cont	Salt	Sulf	Blan	Total
Jonathan	1	3.5	4.4	5.5	3.3	16.7	3.4	3.4	5.0	3.5	15.3
	2	3.9	4.8	5.5	3.6	17.8	3.8	4.3	5.2	3.0	16.3
	3	4.3	5.0	5.0	3.1	17.4	3.5	3.4	5.2	4.3	16.4
	4	3.1	4.6	5.1	4.3	17.1	3.0	4.8	5.8	4.0	17.6
	5	5.1	4.4	5.2	3.6	18.3	4.4	4.1	5.3	3.8	17.6
		19.9	23.2	26.3	17.9	87.3	18.1	20.0	26.5	18.6	83.2
Delicious	1	4.6	4.2	4.2	4.1	17.1	4.3	4.3	4.3	4.0	16.9
	2	4.0	3.5	4.4	3.8	15.7	3.2	4.6	4.1	4.4	16.3
	3	4.3	4.0	4.4	4.2	16.9	4.1	3.9	5.2	5.3	18.5
	4	3.6	5.1	3.5	4.3	16.5	3.8	4.0	5.1	3.1	16.0
	5	4.9	4.9	3.1	4.0	16.9	4.3	3.6	4.4	3.5	15.8
		21.4	21.7	19.6	20.4	83.1	19.7	20.4	23.1	20.3	83.5
Winesap	1	4.6	4.7	4.8	4.8	18.9	3.8	3.8	3.9	3.9	15.4
	2	3.5	4.2	4.6	4.8	17.1	3.6	4.4	3.4	3.3	14.7
	3	4.2	4.3	5.1	4.8	18.4	4.2	3.8	3.5	2.6	14.1
	4	4.6	4.5	4.4	5.0	18.5	4.1	4.1	3.4	3.7	15.3
	5	4.5	4.6	4.5	4.1	17.7	3.9	3.6	4.9	3.4	15.8
		21.4	22.3	23.4	23.5	90.6	19.6	19.7	19.1	16.9	75.3
		62.7	67.2	69.3	61.8	261.0	57.4	60.1	68.7	55.8	242.0

A x R: V		Cont	Salt	Sulf	Blan	Total
Jonathan	1	6.9	7.8	10.5	6.8	32.0
	2	7.7	9.1	10.7	6.6	34.1
	3	7.8	8.4	10.2	7.4	33.8
	4	6.1	9.4	10.9	8.3	34.7
	5	9.5	8.5	10.5	7.4	35.9
		38.0	43.2	52.8	36.5	170.5
Delicious	1	8.9	8.5	8.5	8.1	34.0
	2	7.2	8.1	8.5	8.2	32.0
	3	8.4	7.9	9.6	9.5	35.4
	4	7.4	9.1	8.6	7.4	32.5
	5	9.2	8.5	7.5	7.5	32.7
		41.1	42.1	42.7	40.7	166.6
Winesap	1	8.4	8.5	8.7	8.7	34.3
	2	7.1	8.6	8.0	8.1	31.8
	3	8.4	8.1	8.6	7.4	32.5
	4	8.7	8.6	7.8	8.7	33.8
	5	8.4	8.2	9.4	7.5	33.5
		41.0	42.0	42.5	40.4	165.9
		120.1	127.3	138.0	117.6	503.0

Cont - Control
Salt - Salt
Sulf - Sulfur
Blan - Blanched

Table 5 continued FLAVOR

Source of Variation	D. F.	Ss	Ms	F	Sig
Varieties	2	.3072	.1536	.74	ns
Reps: V (a)	12	2.4745	.2062		
Trt A (Chem)	3	8.3604	2.7868	10.52	***
A x V	6	8.4381	1.4064	5.31	***
A x R: V (b)	36	9.5315	.2648		
Trt B (Sugar)	1	3.0084	3.0084	14.09	***
B x V	2	3.2681	1.6340	7.65	**
A x B	3	.8202	.2734	1.28	ns
A x B x V	6	3.1933	.5322	2.49	*
Error (c)	48	10.2500	.2135		
Total	119	49.6517			

N = 120

Total S = 503.0
SS = 2158.06
- C = 2108.4083
Ss = 49.6517

Varieties SS/40 = 2108.7155
- C = 2108.4083
Ss = .3072

Reps: V SS/8 = 2111.1900
- V SS = 2108.7155
Ss = 2.4745

Trt A SS/30 = 2116.7687
- C = 2108.4083
Ss = 8.3604

Table 5 continued FLAVOR

A x V	SS/10 =	2125.5140	A x B	SS/15 =	2120.5973
	- C =	2108.4083		- C =	2108.4083
- A	Ss =	8.3604	- A	Ss =	8.3604
- V	Ss =	.3072	- B	Ss =	3.0084
	Ss =	8.4381		Ss =	.8202
A x R: V	SS/2 =	2137.5200	A x B x V	SS/5 =	2135.8040
	- C =	2108.4083		- C =	2108.4083
- V	Ss =	.3072	- A	Ss =	8.3604
R: V	Ss =	2.4745	- B	Ss =	3.0084
- A	Ss =	8.3604	- V	Ss =	.3072
A x V	Ss =	8.4381	- A x B	Ss =	.8202
	Ss =	9.5315	- A x V	Ss =	8.4381
			- B x V	Ss =	3.2681
Trt B	SS/60 =	2111.4167		Ss =	3.1933
	- C =	2108.4083			
	Ss =	3.0084			
B x V	SS/20 =	2114.9920			
	- C =	2108.4083			
- B	Ss =	3.0084			
- V	Ss =	.3072			
	Ss =	3.2681			

Table 6 shows the effects of various treatments on the shape of the rehydrated apple varieties.

a. No significant difference was found among varieties due to wide fluctuations in scores.

b. Significant differences were noted among treatments. Mean of total average scores of --

1. Control - - - 121.8 divided by 30 equals 4.06
2. Blanched - - 127.0 divided by 30 equals 4.23
3. Salted - - - 140.4 divided by 30 equals 4.68
4. Sulfured - - 144.4 divided by 30 equals 4.81

Least square difference at .05 level is .37.

a. No significant difference was found between the mean average scores of sulfured and salted treatments, blanched and control treatments.

b. Significant differences were noted between sulfur and blanched treatments, sulfur and control treatments, salted and blanched treatments, and salt and control treatments. Salted and sulfured treatments received the highest mean average scores.

Table 6. Effects of various treatments on shape of rehydrated apple varieties.

		Cooked with 20% sugar					Cooked without 20% sugar				
		Cont	Salt	Sulf	Blan	Total	Cont	Salt	Sulf	Blan	Total
Jonathan	1	3.2	4.4	6.0	3.2	16.8	3.6	4.5	6.1	4.1	18.3
	2	3.6	4.9	5.1	3.4	17.0	4.1	4.8	5.6	3.8	18.3
	3	3.9	5.4	5.1	3.5	17.9	3.4	4.1	6.0	4.6	18.1
	4	3.4	5.0	5.2	5.0	18.6	3.8	5.0	5.5	4.3	18.6
	5	5.2	4.9	4.8	3.4	18.3	3.3	5.8	4.8	3.0	16.9
		19.3	24.6	26.2	18.5	88.6	18.2	24.2	28.0	19.8	90.2
Delicious	1	4.8	5.0	6.0	4.8	20.6	5.2	5.6	5.5	4.3	20.6
	2	4.2	3.4	5.2	3.6	16.4	4.2	5.6	5.3	4.6	19.7
	3	5.8	3.9	4.2	4.8	18.7	4.0	3.2	4.6	5.4	17.2
	4	3.5	5.1	3.5	4.3	16.4	3.0	2.9	4.8	4.3	15.0
	5	4.8	5.0	3.5	3.9	17.2	4.9	4.1	3.5	4.4	16.9
		23.1	22.4	22.4	21.4	89.3	21.3	21.4	23.7	23.0	89.4
Winesap	1	4.5	5.0	4.1	4.5	18.1	3.7	4.7	4.5	4.6	17.5
	2	3.3	5.1	4.0	4.1	16.5	3.2	3.8	3.2	5.9	16.1
	3	4.3	4.9	5.3	4.5	19.0	4.3	5.4	4.6	4.6	18.9
	4	4.6	4.5	3.5	3.9	16.5	4.0	4.4	5.2	3.3	16.9
	5	4.6	5.1	5.0	4.5	19.2	3.4	4.9	4.7	4.4	17.4
		21.3	24.6	21.9	21.5	89.3	18.6	23.2	22.2	22.8	86.8
		63.7	71.6	70.5	61.4	267.2	58.1	68.8	73.9	65.6	266.4

A x R: V		Cont	Salt	Sulf	Blan	Total
Jonathan	1	6.8	8.9	12.1	7.3	35.1
	2	7.7	9.7	10.7	7.2	35.3
	3	7.3	9.5	11.1	8.1	36.0
	4	7.2	10.0	10.7	9.3	37.2
	5	8.5	10.7	9.6	6.4	35.2
		37.5	48.8	54.2	38.3	178.8
Delicious	1	10.0	10.6	11.5	9.1	41.2
	2	8.4	9.0	10.5	8.2	36.1
	3	9.8	7.1	8.8	10.2	35.9
	4	6.5	8.0	8.3	8.6	31.4
	5	9.7	9.1	7.0	8.3	34.1
		44.4	43.8	46.1	44.4	178.7
Winesap	1	8.2	9.7	8.6	9.1	35.6
	2	6.5	8.9	7.2	10.0	32.6
	3	8.6	10.3	9.9	9.1	37.9
	4	8.6	8.9	8.7	7.2	33.4
	5	8.0	10.0	9.7	8.9	36.6
		39.9	47.8	44.1	44.3	176.1
		121.8	140.4	144.4	127.0	533.6

Cont - Control
Salt - Salt
Sulf - Sulfur
Blan - Blanched

Table 6 continued SHAPE

Source of Variation	D. F.	Ss	Ms	F	Sig
Varieties	2	.1172	.0586	.08	ns
Reps: V (a)	12	9.2490	.7708		
Trt A (Chem)	3	11.5174	3.8391	7.39	***
A x V	6	11.8981	1.9830	3.82	**
A x R: V (b)	36	18.7070	.5196		
Trt B (Sugar)	1	.0054	.0054	.01	ns
B x V	2	.2151	.1076	.28	ns
A x B	3	2.2746	.7582	1.96	ns
A x B x V	6	.0869	.0145	.04	ns
Error (c)	48	18.5880	.3872		
Total	119	72.6587			

N = 120

Total
S = 533.6
SS = 2445.40
- C = 2372.7413
Ss = 72.6587

Varieties
SS/40 = 2372.8585
- C = 2372.7413
Ss = .1172

Reps: V
SS/8 = 2382.1075
- V SS = 2372.8585
Ss = 9.2490

Trt A
SS/30 = 2384.2587
- C = 2372.7413
Ss = 11.5174

Table 6 continued SHAPE

A x V	SS/10 =	2396.2740	A x B	SS/15 =	2386.5387
	- C =	2372.7413		- C =	2372.7413
- A	Ss =	11.5174	- A	Ss =	11.5174
- V	Ss =	.1172	- B	Ss =	.0054
	Ss =	11.8981		Ss =	2.2746
A x R: V	SS/2 =	2424.2300	A x B x V	SS/5 =	2398.8560
	- C =	2372.7413		- C =	2372.7413
- V	Ss =	.1172	- A	Ss =	11.5174
- R: V	Ss =	9.2490	- B	Ss =	.0054
- A	Ss =	11.5174	- V	Ss =	.1172
- A x V	Ss =	11.8981	- A x B	Ss =	2.2746
	Ss =	18.7070	- A x V	Ss =	11.8981
			- B x V	Ss =	.2151
Trt B	SS/60 =	2372.7467		Ss =	.0869
	- C =	2372.7413			
	Ss =	.0054			
B x V	SS/20 =	2373.0790			
	- C =	2372.7413			
- B	Ss =	.0054			
- V	Ss =	.1172			
	Ss =	.2151			

Table 7 shows the effects of various treatments on the aroma of the rehydrated apple varieties.

a. No significant difference was found among varieties due to wide fluctuations in scores.

b. Significant differences were noted among treatments. Mean of total average scores of --

1. Control - - - 118.8 divided by 30 equals 3.96
2. Blanched - - 122.1 divided by 30 equals 4.07
3. Salted - - - 131.1 divided by 30 equals 4.37
4. Sulfured - - 136.5 divided by 30 equals 4.55

Least square difference at .05 level comes to .23.

a. No significant difference was found between mean average scores of sulfured and salted treatments, and blanched and control treatments.

b. Significant differences were noted between sulfured and blanched treatments, sulfured and control treatments, salted and blanched treatments, and salted and control treatments. Sulfured and salted treatments received the highest mean average scores.

Table 7. Effects of various treatments on aroma of rehydrated apple varieties.

		Cooked with 20% sugar					Cooked without 20% sugar				
		Cont	Salt	Sulf	Blan	Total	Cont	Salt	Sulf	Blan	Total
Jonathan	1	3.0	4.4	4.8	3.4	15.6	3.2	3.8	5.4	3.1	15.5
	2	3.3	4.8	5.0	3.7	16.8	4.4	4.7	5.1	4.1	18.3
	3	3.8	5.1	5.1	3.1	17.1	3.9	4.2	5.1	4.4	17.6
	4	2.5	4.2	4.8	3.8	15.3	3.0	4.7	5.0	4.0	16.7
	5	5.1	4.4	4.9	3.8	18.2	3.5	4.6	5.0	3.5	16.6
		17.7	22.9	24.6	17.8	83.0	18.0	22.0	25.6	19.1	84.7
Delicious	1	4.4	4.5	4.4	3.7	17.0	4.6	4.2	4.0	4.1	16.9
	2	4.1	4.0	4.8	4.6	17.5	3.9	5.0	4.5	4.4	17.8
	3	4.3	4.2	4.1	3.3	15.9	4.5	3.8	4.9	4.9	18.1
	4	3.3	4.5	3.6	4.3	15.7	3.6	4.0	4.5	4.0	16.1
	5	5.0	4.8	3.6	4.2	17.6	4.3	4.4	4.4	4.9	18.0
		21.1	22.0	20.5	20.1	83.7	20.9	21.4	22.3	22.3	86.9
Winesap	1	4.3	4.6	4.0	5.1	18.0	4.1	4.1	4.1	4.4	16.7
	2	3.8	4.4	4.3	4.3	16.8	3.7	4.0	3.9	4.2	15.8
	3	4.3	4.5	4.6	4.2	17.6	4.5	4.5	4.6	3.9	17.5
	4	4.4	4.3	4.1	4.5	17.3	4.0	4.2	4.2	4.0	16.4
	5	4.2	4.2	4.3	4.2	16.9	3.8	4.1	5.4	4.0	17.3
		21.0	22.0	21.3	22.3	86.6	20.1	20.9	22.2	20.5	83.7
		59.8	66.9	66.4	60.2	253.3	59.0	64.3	70.1	61.9	255.3

A x R: V		Cont	Salt	Sulf	Blan	Total
Jonathan	1	6.2	8.2	10.2	6.5	31.1
	2	7.7	9.5	10.1	7.8	35.1
	3	7.7	9.3	10.2	7.5	34.7
	4	5.5	8.9	9.8	7.8	32.0
	5	8.6	9.0	9.9	7.3	34.8
		35.7	44.9	50.2	36.9	167.7
Delicious	1	9.0	8.7	8.4	7.8	33.9
	2	8.0	9.0	9.3	9.0	35.3
	3	8.8	8.0	9.0	8.2	34.0
	4	6.9	8.5	8.1	8.3	31.8
	5	9.3	9.2	8.0	9.1	35.6
		42.0	43.4	42.8	42.4	170.6
Winesap	1	8.4	8.7	8.1	9.5	34.7
	2	7.5	8.4	8.2	8.5	32.6
	3	8.8	9.0	9.2	8.1	35.1
	4	8.4	8.5	8.3	8.5	33.7
	5	8.0	8.3	9.7	8.2	34.2
		41.1	42.9	43.5	42.8	170.3
		118.8	131.2	136.5	122.1	508.6
		(3.96)	(4.37)	(4.55)	(4.07)	

Cont - Control
Salt - Salt
Sulf - Sulfur
Blan - Blanched

Table 7 continued AROMA

Source of Variation	D. F.	Ss	Ms	F	Sig
Varieties	2	.1272	.0636	.23	ns
Reps: V (a)	12	3.3115	.2760		
Trt A (Chem)	3	6.6350	2.2117	11.68	***
A x V	6	7.9235	1.3206	6.98	***
A x R: V (b)	36	6.8165	.1893		
Trt B (Sugar)	1	.0334	.0334	.21	ns
B x V	2	.5051	.2526	1.56	ns
A x B	3	.7660	.2553	1.58	ns
A x B x V	6	.5095	.0849	.52	ns
Error (c)	48	7.7760	.1620		
Total	119	34.4037			

N = 120

Total
S = 508.6
SS = 2190.02
- C = 2155.6163
Ss = 34.4037

Varieties
SS/40 = 2155.7435
- C = 2155.6163
Ss = .1272

Reps: V
SS/8 = 2159.0550
- V SS = 2155.7435
Ss = 3.3115

Trt A
SS/30 = 2162.2513
- C = 2155.6163
Ss = 6.6350

Table 7 continued AROMA

A x V	SS/10 =	2170.3020	A x B	SS/15 =	2163.0507
	- C =	2155.6163		- C =	2155.6163
- A	Ss =	6.6350	- A	Ss =	6.6350
- V	Ss =	.1272	- B	Ss =	.0334
	Ss =	7.9235		Ss =	.7660
A x R: V	SS/2 =	2180.4300	A x B x V	SS/5 =	2172.1160
	- C =	2155.6163		- C =	2155.6163
- V	Ss =	.1272	- A	Ss =	6.6350
- R: V	Ss =	3.3115	- B	Ss =	.0334
- A	Ss =	6.6350	- V	Ss =	.1272
- A x V	Ss =	7.9235	- A x B	Ss =	.7660
	Ss =	6.8165	- A x V	Ss =	7.9235
			- B x V	Ss =	.5051
Trt B	SS/60 =	2155.6497		Ss =	.5095
	- C =	2155.6163			
	Ss =	.0334			
B x V	SS/20 =	2156.2820			
	- C =	2155.6163			
- B	Ss =	.0334			
- V	Ss =	.1272			
	Ss =	.5051			

SUMMARY

The fruits of three varieties of apples, viz. Jonathan, Delicious, and Winesap were dried by sun-drying, freeze-drying and drying at temperatures of 130° F and 160° F. Some of the fruits were fried in vegetable shortening for making apple chips.

The fruits dried by sun-drying, after being treated with sulfur, were whiter in color but were poor in texture and shape. The dried, untreated slices were dark in appearance. On the whole, fruits of inferior quality developed off flavors and became moldy. Spoilage was due to high moisture content. The sun-drying was done in the fall when the sun was not as bright as was desirable and the humidity was high during the nights.

The fruits dried by freeze-drying were of superior quality. The sulfur treated samples had a good texture and flavor and were white in color. The dried apple slices maintained their original shape and were not shrivelled which may be due to the extraction of liquids from the apple slices in the form of vapors. In resume, freeze-dried samples had a good color, flavor, texture, aroma, and shape and stored well but due to the requirement of high technical skill and the unavailability of the equipment on a large scale this method was considered to be impractical for large scale use in India.

Little difference was found in the quality of dried apples between the fruits dried at 130 F and 160 F. The fruit treated with salt was whiter but was tough in texture. The fruit treated with sulfur before drying was white and had a good texture. Control or untreated dried samples were brown with a medium texture. The samples blanched before drying were shrivelled in appearance and were light brown with a medium texture.

Apple chips fried for one minute became moldy within a few days while others fried for two minutes were too dark in color. The apple chips fried in vegetable shortening containing anti-oxidant (Butylated Hydroxy Anisole and Butylated Hydroxy Toluene) were light in color but the results were not satisfactory.

The fruits dried by sun-drying were discarded because they were inferior in quality and became moldy due to the high percentage of moisture.

Freeze-dried slices were of good quality but this method of dehydrating was not followed because it required a high technical skill and the equipment needed for this method is not available in India.

The fried apple chips became dark in color and were not agreeable in taste.

Little difference was found in fruits dried at 130° F and 160° F. Since the equipment for drying at 130° F was readily available this method was considered to be more suitable for the present experiment.

Since the fruit must be rehydrated for consumption a study was made of the methods of reconstituting the dried fruit.

Three varieties of apples, Delicious, Jonathan, and Winesap, after sorting, peeling, coring, trimming, slicing, and treating with sulfur, salt, blanching, and no treatment (control) were dried at 130° F for 72 hours. After drying, the fruit was rehydrated, cooked with and without sugar, and was judged by a panel, scoring for aroma, color, shape, flavor, and texture. The panel scored five replications of each variety.

The main objective of this problem was to find which variety and treatment, when dried and rehydrated in a specified manner gave the most satisfactory product. The data was subjected to a statistical analysis. For the sake of sim-

plicity six charts and seven tables were prepared. The statistical analysis of variance revealed the following information:

a. No significant difference was found among the three varieties so far as aroma, color, shape, flavor, and texture of rehydrated apples is concerned.

b. Regarding the flavor of rehydrated apples, the sulfur treatment gave significantly better results.

c. Sulfur and salt treatments had a beneficial effect on aroma, color, shape, and texture of the rehydrated apples as a significant difference was found in favor of the sulfur and salt treatment as compared to blanching and control treatment.

d. Sulfur and salt had almost an equal effect on the quality of apples because no significant difference was found among the average scores of sulfured and salted samples except in the case of flavor. Sulfured fruit received a higher score in flavor than salted samples.

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DEHYDRATION AND REHYDRATION OF APPLES

by

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With improvements in the standard of living of the people of India their tastes are gradually shifting from dried fruits towards fresh fruits. The lack of refrigeration and storage facilities are hurdles in the way of supplying fruits in the fresh state during off seasons. Much spoilage occurs during the harvest season. At present the only practical way to cope with the demand for fruit in that country is to dry the fresh fruit by good methods and then to rehydrate it in such a way that rehydrated fruit will closely resemble the fresh fruit, especially with respect to flavor, aroma, shape, color and texture.

Fruits were dried by sun-drying, freeze-drying, and drying at temperatures of 130° F and 160° F. Some fruits were fried in vegetable shortening for making apple chips.

The fruits dried by sun-drying after being treated with sulfur were whiter in color but were poor in texture and shape. The dried untreated slices were dark in appearance. On the whole, the fruits were of an inferior quality, developed off-flavors and became moldy. Spoilage was due to the high moisture content. The sun-drying was done in the fall when the sun was not as bright as was desirable and during the nights the humidity was high.

The fruits dried by freeze-drying were of superior quality. Sulfur treated samples had a good texture and flavor and were whiter in color. The dried apple slices maintained their original shape and were not shrivelled which may be due to the extraction of liquids from the apple slices in the form of vapors. Although freeze-dried samples had a good color, flavor, aroma, shape, and texture and stored well this method was considered to be impractical for use in India due to the requirements of high technical skill and the unavailability of the necessary equipment.

Little difference was noted in the quality of dried apples between the fruits dried at 130° F and 160° F. The fruits treated with salt were whiter in color but were tough in texture. The fruits treated with sulfur before drying were whiter in color and had a good texture. Control untreated dried samples were brown in color with a medium texture. The samples blanched before drying were shrivelled in appearance and were light brown in color with a medium texture.

Apple chips fried for one minute became moldy within a few days while others fried for two minutes were dark in color. The apple chips fried in vegetable shortening containing anti-oxident (Butylated Hydroxy Anisole and Butylated Hydroxy Toluene) were lighter in color but the results were not satisfactory.

Since dried fruit must be rehydrated for consumption a study was made of the methods of reconstituting the dried fruit.

After sorting, peeling, coring, trimming, slicing, and treating with sulfur, salt, blanched, and no treatment (control) three varieties of apples, Delicious, Jonathan, and Winesap were dried at 130° F for 72 hours. After the fruit was rehydrated and cooked with and without 20% sugar it was judged by a panel, scoring for aroma, color, shape, flavor, and texture. The panel scored five replications of each variety and treatment.

The main objective of this problem was to find which variety and treatment, when dried and rehydrated in a specified manner, gave the most satisfactory product.

The data was subjected to statistical analysis. For the sake of simplicity, six charts and seven tables were prepared. The statistical analysis of variance revealed the following information:

a. No significant difference was found among three varieties as far as aroma, color, shape, flavor, and texture of rehydrated apples is concerned.

b. Regarding the flavor of rehydrated apples, the sulfur treatment gave significantly better results.

c. Sulfur and salt treatments had a beneficial effect on aroma, color, shape, and texture of rehydrated apples, as significant differences were found in favor of the sulfur and salt treatments as compared to blanching and control treatments.

d. Sulfur and salt had almost equal effect on the quality of the apples because no significant differences were found among the average scores of sulfured and salted samples except in the case of flavor. Sulfured fruit got a higher score in flavor than the salted samples.